SODAR NETWORK SUPPORT FOR LIRAQ UTILIZATION IN CONJUNCTION WITH PROJECT MABLE

Final Report

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This report was submitted in fulfillment of ARB Contract Number A7-184-30 ("Sodar Network Support for LIRAQ Utilization in Conjunction with Project MABLE") by SRI International under the sponsorship of the California Air Resources Board. Work was completed as of 3 October 1979.

DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as either an actual or an implied endorsement of such products.

I CONCLUSIONS

The purpose of this project was to collect mixing depth data, convert it to an easily usable form, and distribute it to others for use in air quality and boundary layer studies. This collection, conversion, and distribution were accomplished satisfactorily. Thus the results of this project reinforce the conclusion reached in an earlier study (Russell and Uthe, 1978b) that sodar network measurements in the San Francisco Bay area can provide long-term, hourly data on spatial variations of mixing depth and stability in a digital format readily usable in air quality simulation models.

The positive result is a direct consequence of the Bay area's special, marine-influenced meteorology, which is characterized by frequent low, strong, elevated inversions. These inversions are easily detected by commercial sodars of moderate power; moreover, they yield sodar facsimile records that are relatively easy to interpret. In general, at sites located progressively inland, the frequency, strength, and low altitude of these inversions are progressively moderated, and as a consequence an unambiguous mixing depth can be determined from sodar data a decreasing fraction of the time. This effect was evident in comparing the overall data sets from land- and marine-influenced sites in the present study. Nevertheless, the digitized sodar data consistently gave quantitative measurements of the small mixing depths conducive to the development of air pollution episodes.

This study has also shown that automatic plotting routines can easily convert the digital sodar data to graphs of mixing-depth and stability indicators. These graphs give an overview of large volumes of mixing information and are easier to comprehend than either the original facsimile records or listings of the digital data. Hence they facilitate rapid comparisons among different sites, days, and times of day.

Careful site selection and expert maintenance of sodar hardware continue to be of paramount importance in achieving satisfactory data quality and high data-capture fractions.

II RECOMMENDATIONS

On the basis of the foregoing conclusions, we recommend that:

- The digital data produced in this study continue to be used in conjunction with LIRAQ and other modeling studies of Bay area air quality.
- The filming, digitizing, and plotting techniques used in this study be applied to other sodar data sets intended for use in air quality studies.
- The possible benefits and costs of maintaining several sodar sites at selected Bay area locations in air pollution seasons be carefully considered.

III INTRODUCTION

A. LIRAQ Data Requirements

The LIRAQ (Livermore Regional Air Quality) model is a tool for simulating the air quality consequences of specified sets of pollutant emissions and meteorological conditions in regions of complex terrain. The model was originally developed for the San Francisco Bay area. It has been and is now being used extensively in the Air Quality Maintenance Planning Process in the Bay area to develop an attainment plan for reactive and nonreactive pollutants.

To function properly, LIRAQ requires hourly meteorological data specifying boundary-layer winds and mixing depth throughout the modeled region. These quantities can vary markedly with space and time in the Bay area because of the area's complex topography, varied surface characteristics, and the varying influence of Pacific weather systems. Hence, a complete and accurate specification of winds and mixing depth requires frequent measurements from many locations. Making such measurements with direct sensors (e.g., on towers, airplanes, or balloons) is extremely expensive. In particular, LIRAQ is sensitive to mixing-depth data, and such vertical data have been very difficult to obtain with the needed space and time resolution.

B. Sodar Network Capabilities

Studies by Russell and Uthe (1978a,b) had earlier shown that a network of sodars (acoustic radars) operating in the Bay area could provide information on mixing depth (and surface stability) with the spatial and temporal detail required for input to LIRAQ. Moreover, it had been shown that this information could be expressed in an hourly, digital form that is computer-readable and easily understood by a user with no sodar experience. Once expressed in this digital form, the sodar-derived mixing-depth information can be used to make contour maps that show the changing shape of the mixing-top surface and its relation to the topography, to surface heating and cooling, and to other factors. In turn, this information on the upper boundary of the mixing layer can be used in wind-field generating schemes that produce a mass-consistent, three-dimensional boundary-layer wind field from sparse data (e.g., Dickerson, 1978; Sherman, 1978; Bhumralkar et al., 1978). This is the information LIRAQ and its preprocessor code MASCON require to expand LIRAQ's library of prototype meteorological days. Previous sodar network data have been useful in this regard.

Although the sodar-derived information on mixing depth can sometimes be ambiguous, extensive comparisons (e.g., Russell and Uthe, 1978a,b) have shown that, in the San Francisco Bay area, sodar data ambiguities are no greater than the ambiguities encountered in using conventional means to measure mixing depth (i.e., balloon soundings to obtain temperature and humidity profiles), provided that sodar sites are carefully selected and the sodars are carefully maintained. Moreover, since the sodars operate economically and continuously, they can be used in networks to provide a more complete spatial and temporal picture of boundary-layer behavior than is practical by any other means.

C. Project MABLE

The summer of 1978 presented an unusual opportunity to gather input data sets for use in expanding the LIRAQ meteorological library. Project MABLE (Marine Atmospheric Boundary Layer Experiment) was conducted during late July and August. The goal of MABLE was to improve understanding of the marine boundary layer offshore of San Francisco and of its modification as it moves inland over the coastal land mass. Meteorological sensors on two research ships, the NCAR (National Center for Atmospheric Research) Queen Air aircraft, the Mt. Sutro tower [250 to 500 m above sea level (ASL) in the center of San Francisco], and the Farallone Islands (50 km offshore) produced the most complete data set yet available on the offshore and coastal boundary layer in the San Francisco area. In particular, sodar data were acquired from the Farallones and one research ship, and are now being combined with airplane and tower data to generate a picture of marine boundary-layer depth variations in space and time.

Project MABLE is thus providing to LIRAQ data describing marine inflow and the resulting behavior of the boundary layer near the coast. However, to be of full usefulness to LIRAQ, these new, more comprehensive MABLE data must be supplemented by simultaneous measurements of the inland behavior of the Bay area boundary layer. A very important use of such a combined offshore, coastal, and inland data set would be in expanding LIRAQ's ability to simulate summertime oxidant episodes, which occur most frequently during the late-July and August period when MABLE was conducted.

D. Overview of This Project

The purpose of this project was to supply the hourly mixing-depth data most critically required by LIRAQ to simulate summer oxidant episodes in conjunction with MABLE data. The large open circles in Figure 1 show the seven areas where LIRAQ requires mixing-depth information for this purpose. These locations were determined by staff of the Bay Area Air Quality Management District (BAAQMD) after careful study of previous LIRAQ verification efforts and available meteorological and pollutant data.

SRI contracted to operate a network of rented sodars for the month of August 1978 at sites within the five most crucial areas shown in Figure 1. These sites, marked by dots in Figure 1, are Napa, Benicia, Walnut Creek, Livermore, and San Jose. In addition, a sixth sodar, owned by SRI, was simultaneously operated at SRI in Menlo Park. After the field program, SRI conferred with BAAQMD personnel to identify prime cases for LIRAQ utilization. The data for these and other cases were then reduced to digital form suitable for LIRAQ input. Digital data and a film copy of the facsimile data were supplied to BAAQMD, to MABLE personnel at San Jose State University, and to the California Air Resources Board. In addition, computer plots of the digital data were produced to

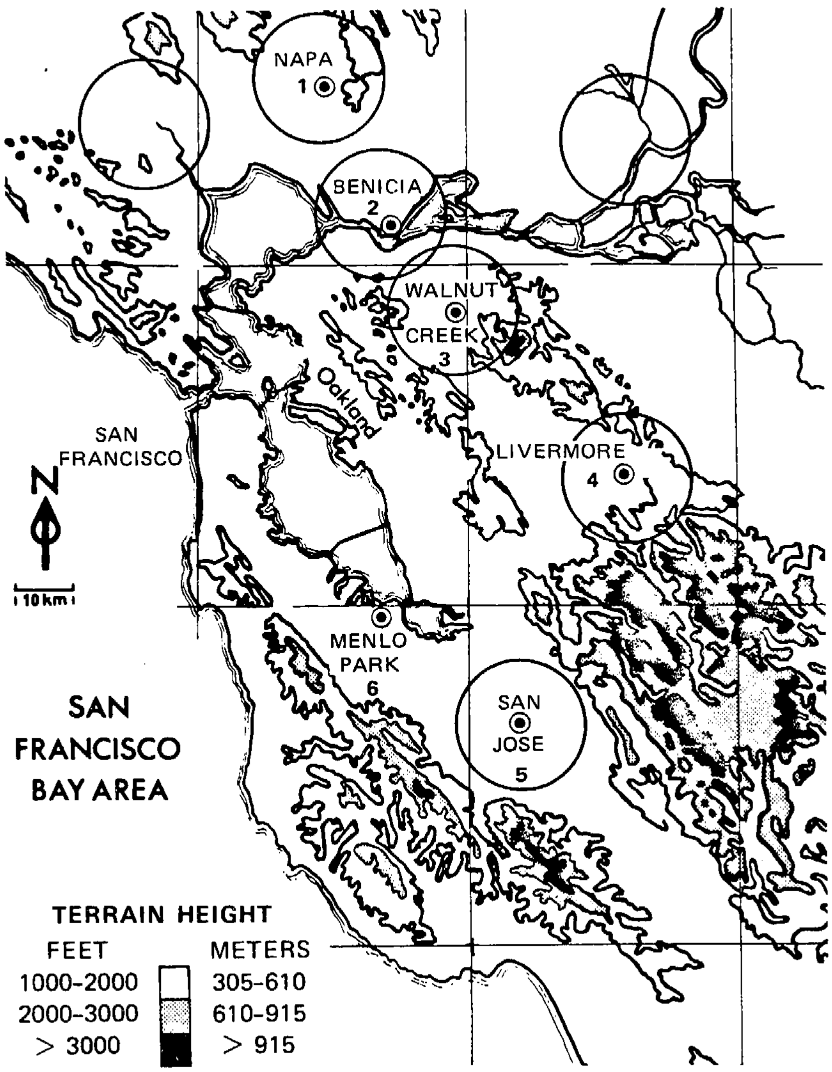


FIGURE 1 SODAR LOCATIONS IN THE 1978 BAY AREA NETWORK

Numbered dots mark sodar locations. Large open circles mark areas where inland mixing-depth information is most critically required by LIRAQ to supplement MABLE data in simulating summer oxidant episodes.

aid in user comprehension of the complete data set and to facilitate comparisons among different sites, days, and times of day.

The remainder of this report gives the details of these project operations and shows and discusses the data.

IV NETWORK AND EQUIPMENT OPERATION

In June and July 1978, field surveys were conducted to locate suitable sodar sites, and permission for use was obtained from site owners. The sites thus selected are those shown in Figure 1 and listed in Table 1. In addition, six SRI-owned acoustic enclosures, used in a previous network study, were refurbished with new acoustic foam, paint, and necessary hardware.

Table 1

1978 SODAR NETWORK SITES

No.	Name	UTM Coordinates (km)		Height* (m ASL)
		x	y	
1	Napa	563	4236	5
2	Benicia	575	4213	49
3	Walnut Creek	584	4197	30
4	Livermore	616	4174	186
5	San Jose	599	4132	68
6	Menlo Park	573	4145	18

*All sodars were located at ground level, except Site 5 (San Jose), which was atop an 8-story building.

Five monostatic sodars (Model 300-001) were rented from Aerovironment, Inc. for July-September 1978. Initially, these sodars and a similar SRI-owned sodar (also Aerovironment Model 300-001) were tested, intercompared, and adjusted at SRI over a two-week period, to assure that all six sodars displayed the same acoustic echo structure when viewing the same atmosphere. In late July the six sodars and enclosures were installed at their field sites.

The network was operated from the last few days of July through the first few days of September 1978. Throughout this period, each of the six sodars was checked every other day, on average. A supply of spare parts was maintained, and a technician was kept on call to make necessary repairs rapidly, so that a data capture rate of better than 90 percent was attained. Figure 2 shows the data log.

In early September all sodars were returned to SRI, and the intercomparison tests were repeated. Although necessary adjustments and repairs had been made to several of the sodars, all six sodars at the end of the experiment were found to display the same acoustic echo structure when viewing the same atmosphere. The five rental sodars were returned to Aerovironment, and the network enclosures were returned to SRI.

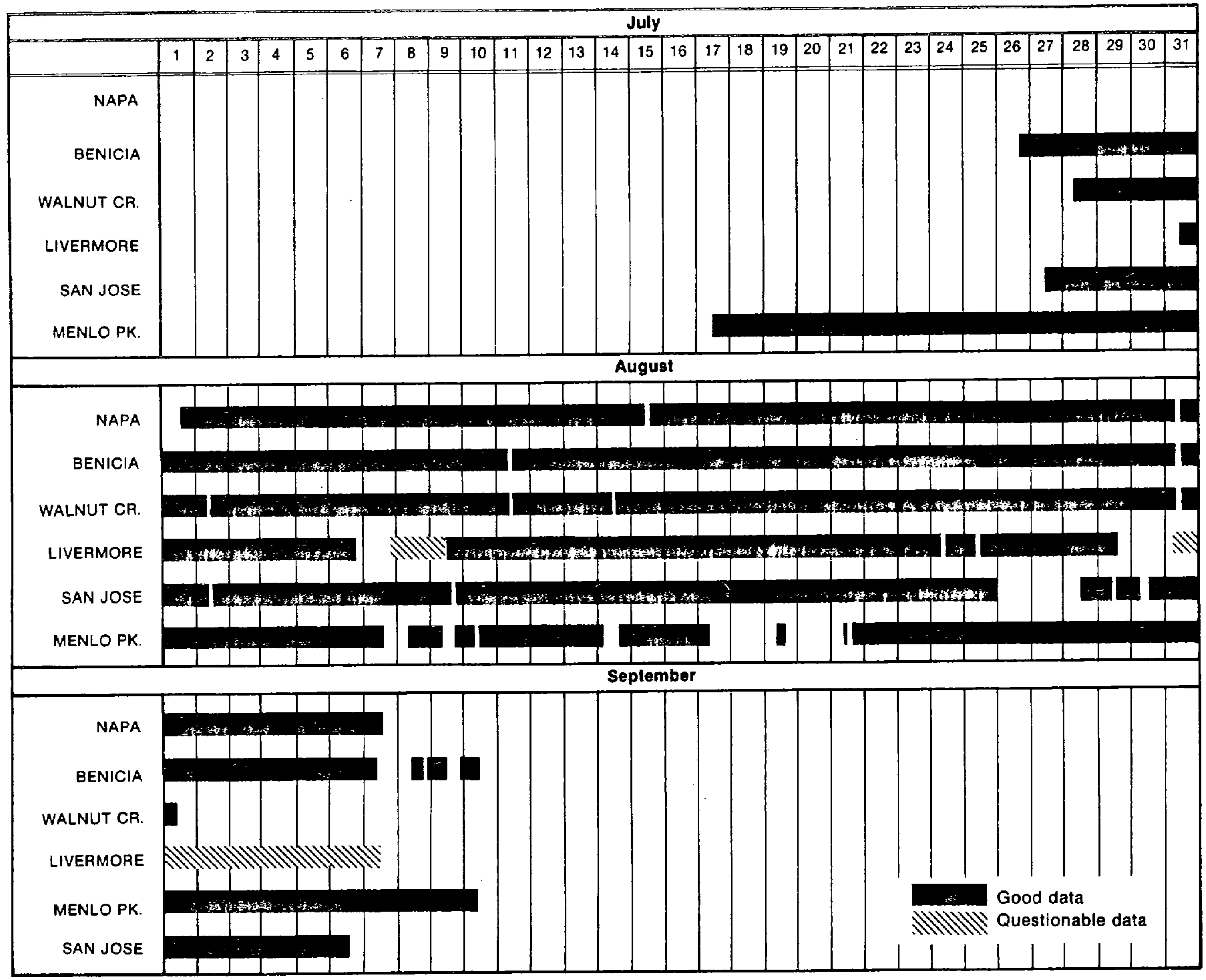


FIGURE 2 LOG OF FACSIMILE DATA — 1978 SODAR NETWORK

V DATA REDUCTION AND DISTRIBUTION

The complete set of sodar facsimile records from each site was photographed against a background that automatically provided height and time scales and site and date identifiers. Examples of the resulting displays have previously been published by Russell and Uthe (1978b). Film copies of the complete facsimile data set were sent to the Bay area Air Quality Management District (BAAQMD), San Jose State University (SJSU), and the California Air Resources Board (CARB).

SRI project personnel conferred with personnel at BAAQMD and SJSU to select the sodar data periods of greatest value to LIRAQ oxidant-episode modeling and MABLE boundary-layer studies. It was agreed that 4-8 August would be the oxidant-episode period, and 2-11 August would be the MABLE boundary-layer period. On the basis of these requirements and the quality and intrinsic interest of the sodar records, we decided to digitize the sodar data for all site-days from 28 July through 15 August 1978. With missing site-days deleted, a total of 93 site-days were digitized, slightly in excess of the contractually required 90.

The data were digitized manually according to a modification of the method described by Russell and Uthe (1978b). This modified method is described in Apprndix A. It yields for each hour at each site an hourly-average estimate of mixing depth and a character that indicates whether surface conditions are stable, convectively unstable, or unknown (on the basis of the sodar data). The complete set of digital data is listed in Appendix A. Cards and listings of the digital data were sent to BAAQMD, SJSU, and CARB.

Although the filmed and digital data described above constitute the complete set of contractually required data products for this project, another data product was developed to assist in data use. A computer program that plots mixing depth and surface-stability symbols as a function of site and time was developed. A complete set of plots produced by this program is included in Appendix B. This set of plots was also distributed to BAAQMD and SJSU.

The plotting program was also used to produce still more compact data products. For example, Figure 3 shows a single plot of hourly mixing-depth estimates at all six sites for the complete digitization period (28 July-15 August). Figure 3 gives a quick overview of mixing-depth trends and the major differences between different sites, days, and times of day. For clarity, the surface-stability symbols are omitted from Figure 3. However, it should be noted that the surface-stability symbol "?" indicates that the associated mixing-depth estimate is only an upper bound. (See Appendix A and Section VI.) Thus, detailed interpretation of the sodar data should always consider the mixing-depth estimates and surface-stability symbols together, or should at least distinguish mixing-depth upper bounds from best estimates.

Figures 4 and 5 are included to show more detailed views of the mixing-depth and stability plots. Figure 4 spans 2-11 August 1978 (the SJSU boundary-layer study period), and Figure 5 spans 4-8 August (the BAAQMD oxidant-episode study period). Both figures use special symbols to distinguish mixing-depth best estimates from upper bounds. (The highly compressed time scale prevented clear use of such symbols in Figure 3.) In addition, Figure 5 shows surface-stability symbols. Surface-stability symbols for all site-days are included in the expanded-scale plots of Appendix B.

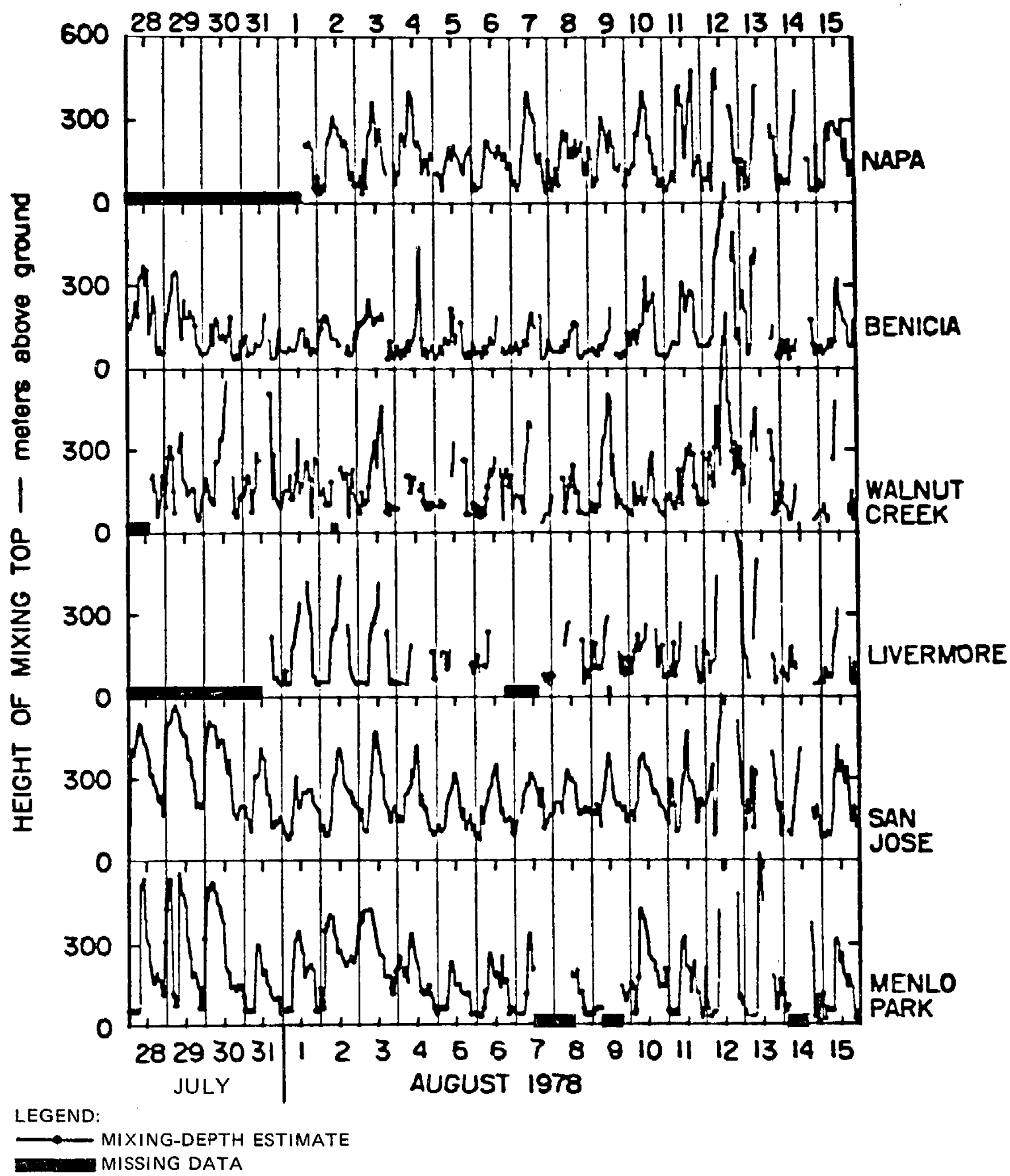


FIGURE 3 HOURLY MIXING-DEPTH ESTIMATES FOR ALL SITES — 28 JULY – 15 AUGUST 1978

Date tick marks are at noon Pacific Standard Time. See Figures 4-5 and Appendix B for surface-stability symbols and indicators of mixing-depth estimates that are upper bounds.

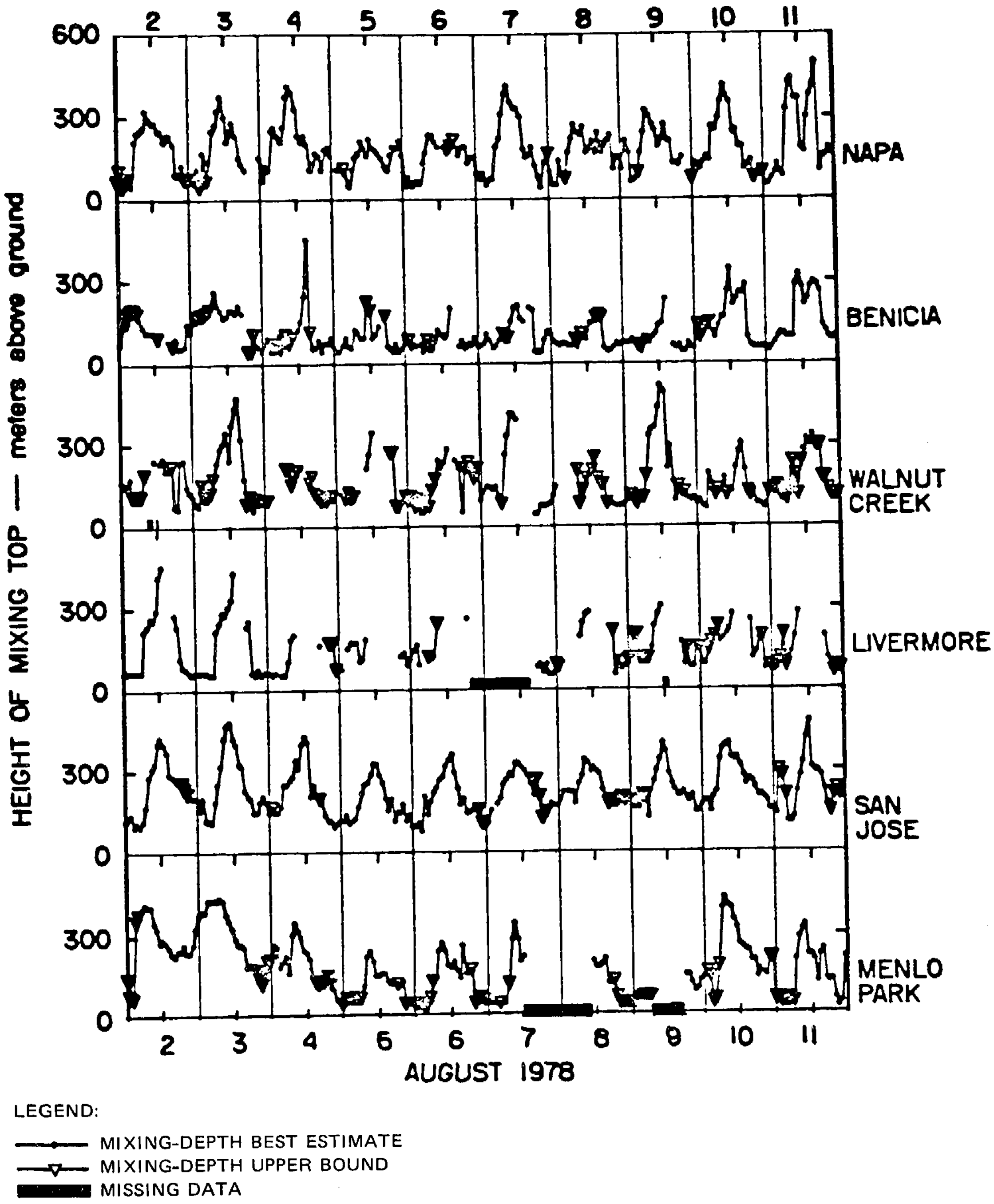
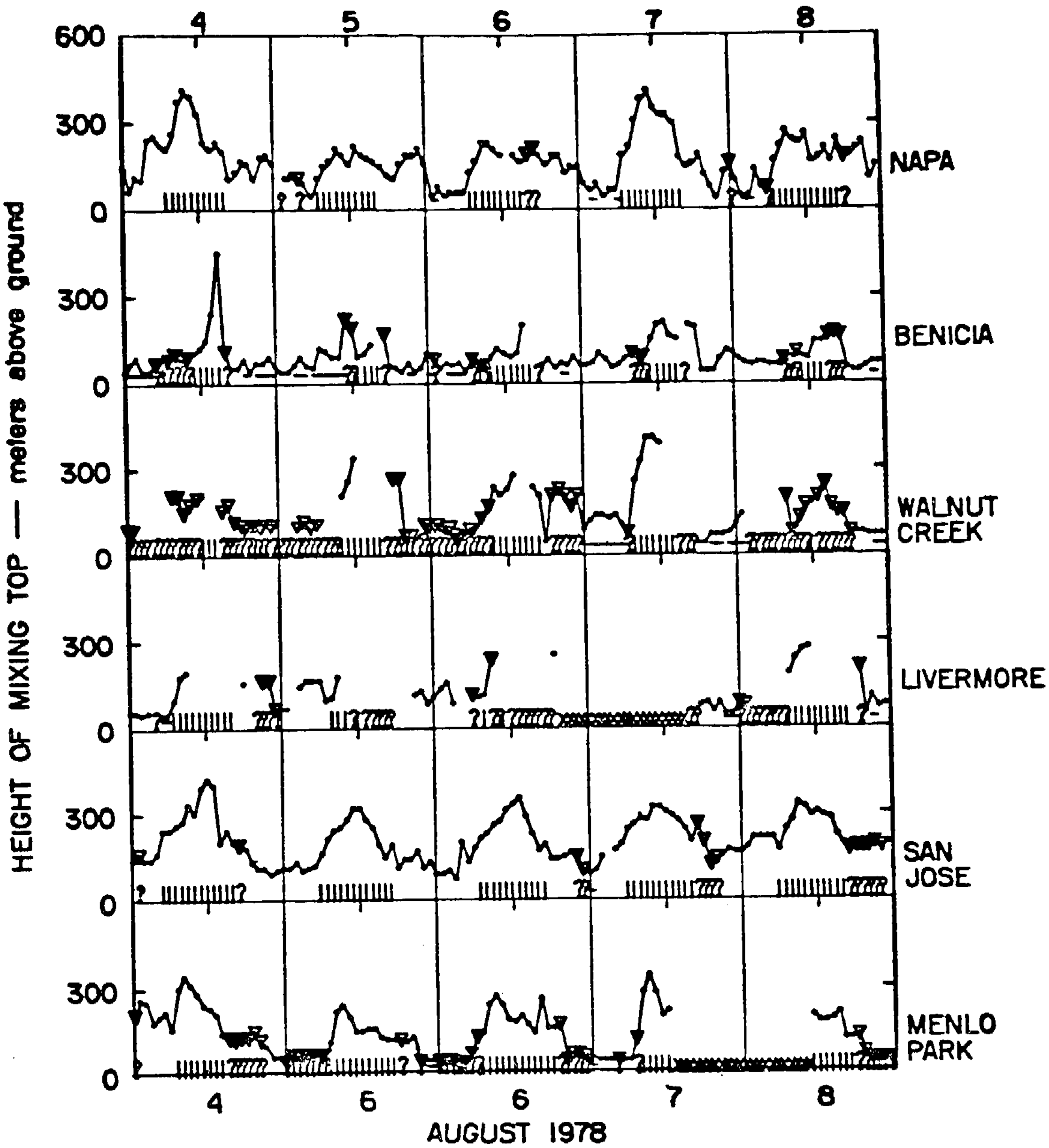


FIGURE 4 HOURLY MIXING-DEPTH ESTIMATES FOR ALL SITES — 2-11 AUGUST 1978

Date tick marks are at noon Pacific Standard Time. See Figure 5 and Appendix B for surface-stability symbols.



LEGEND:

MIXING-DEPTH BEST ESTIMATE

MIXING-DEPTH UPPER BOUND

XXXXX MISSING DATA

I SURFACE CONVECTION

— SURFACE STABILITY

??? AMBIGUOUS SURFACE ECHO

FIGURE 5 HOURLY MIXING-DEPTH ESTIMATES AND SURFACE STABILITY SYMBOLS FOR ALL SITES — 4-8 AUGUST 1978

Date tick marks are at noon Pacific Standard Time.

VI DISCUSSION

A. Overview of Mixing-Depth Results

It can be seen readily from Figures 3-5 that, on average, daytime summer mixing depths in the San Francisco Bay area are much smaller than those in typical midlatitude continental areas. Many studies (e.g., Benkley and Shulman, 1979; Endlich et al., 1979) have shown that summertime afternoon mixing depths rise to 1-2 km or more above ground level (AGL) in continental locations, whereas Figures 3-5 show Bay area mixing depths at many sites typically restricted to less than 600 m AGL for days or weeks at a time. This restriction is especially prevalent at the more marine-influenced sites (Benicia, Menlo Park, San Jose, Napa). At Livermore, the site most isolated from marine influences (see Figure 1), this restriction is moderated, and on many days (e.g., 1-4 and 10-11 August) the afternoon mixing top in Livermore becomes weak and high enough to escape sodar detection, even when it is simultaneously detected below 500 m AGL at the more marine-influenced sites. It has frequently been noted (e.g., Benkley and Shulman, 1979) that moderately powered commercial sodars (as used in this project) are typically unable to detect the mixing top after late morning during summertime at continental sites, because the top has risen above sodar range. Thus, conditions at Livermore approach those at more continental sites. Nevertheless, some marine influence is evident; mixing depths do remain below 600 m AGL until solar noon or later on many days.

Figures 3-5 show clearly that the period 4-8 August had some of the smallest daytime mixing depths of the 28 July-15 August digitization period. This is significant, because BAAQMD did not use sodar data in selecting 4-8 August as the oxidant-episode period.

B. Special Cases

1. Livermore--5-6 August

The Livermore sodar data for 5 and 6 August require special discussion. On these days the mixing top was very low (<300 m AGL) at all other sites. In fact, during both afternoons, the mixing top in Menlo Park was at or below ground level at Livermore (186 m above sea level; cf. Table 1). The Livermore sodar records showed no well-defined mixing top (elevated layer echo) on the afternoons of 5 and 6 August, and the surface echoes, which are usually well-defined spikes during this convective period, were small, indistinct, and difficult to interpret. (Both the lack of a sodar-detected mixing top and the "?" indicator for surface echoes during this time can be seen in Figure 5.)

The lack of an elevated layer echo and the unusual surface echoes may reflect actual atmospheric behavior. Specifically, large-scale subsidence (evidenced by the low mixing top at other sites) may have caused the usually elevated inversion to be near ground level at Livermore. At such a level it may have inhibited afternoon convection (causing the unusual surface echoes), while it was simultaneously destroyed by surface heating (causing the absence of an elevated layer echo). However, we have no evidence from previous studies to suggest that this process occurs, and the unusual records may have been caused by equipment problems. Late on 6 August the facsimile recorder for the Livermore sodar failed. (This was discovered on 7 August, and the Livermore sodar was then replaced by the Menlo Park sodar; the malfunctioning sodar was repaired and put back into service in Menlo Park on 8 August.) The unusual records produced on 5 and 6 August at Livermore may have been symptomatic of the early stages of recorder failure. It is possible that a properly functioning sodar at Livermore on 5 and 6 August would have produced a continuous, or nearly continuous, record of a low mixing top, as was recorded at the other sites.

Use of the tabulated sodar data according to the rules of Table A-1, Appendix A will produce the proper interpretation for the 5-6 August Livermore data, without resolution of the above questions. (This proper interpretation is, "no mixing-depth measurement" whenever the mixing-depth entry is "99" and the surface echo indicator is "?," as occurred for most afternoon hours on 5-6 August at Livermore. See Figure 5.) However, this discussion is presented here to explain the unusual occurrence of afternoon "?" surface-echo symbols at Livermore on 5 and 6 August.

2. Ambiguous Echoes at Walnut Creek

The frequent occurrence of "?" surface-echo indicators and associated "upper bound" mixing-depth symbols at Walnut Creek can be traced to site selection. (Appendix A explains why "?" and "upper bound" indicators are linked. See also the end of this section.) The Walnut Creek sodar was originally set up inside an abandoned open-top water tank. It appeared that this tank would be an ideal site because it would provide very good acoustic shielding of the sodar from surrounding neighbors and background noise sources. However, we eventually discovered that the tank reverberated after being insonified by the transmitted sodar pulse, thus creating a nonatmospheric echo source. These "false" echoes depended to a certain extent on temperature and other factors; thus their presence was intermittent and their source unclear. Only after studying several weeks of facsimile records did the magnitude of the problem become apparent, and the possibility of tank reverberations was then suggested. On 14 August we moved the Walnut Creek sodar out of the tank and into the SRI trailer-mounted enclosure (moved to the Walnut Creek site for this purpose). The false echoes disappeared, and the Walnut Creek sodar was operated satisfactorily in the trailer for the duration of the project. (Note the lack of "?" indicators in the 15 August Walnut Creek data in Appendix B.)

The false echoes on the Walnut Creek records are confined to heights below about 80 m and tend to obscure actual atmospheric echoes in that region. During daytime periods of strong convection, the convective spike echoes usually rise above the false echoes, and the true echo type can be identified. At other times, however, the false echoes prevent identification of the true echoes. This is the reason for the large number of "?" surface-echo type indicators in the Walnut Creek data prior to noon on 14 August. When surface-echo type is unknown, one must acknowledge the possibility that a stable layer is present at the surface. Thus, the height of the lowest unambiguous layer echo (entered as the mixing-depth estimate) is only an upper bound for actual mixing depth in such cases. (See Appendix A for more detailed explanation.) The special "upper bound" plotting symbols are therefore used for mixing depth in Figure 5 and Appendix B whenever the surface echo type indicator is "?."

C. Relationship between Symbol Code and Equipment and Siting Problems

Figure 5 shows that in many cases the "upper bound" value for mixing depth is quite close to ground, and thus the practical difference between "upper bound" and "best estimate" is small. Even in cases where the upper bound is not small, having an upper bound is better than having no information at all. Nevertheless, the value given is an upper bound and not a best estimate: thus the choice of symbols and plotting conventions shown.

Many of the "?" surface-echo symbols at Menlo Park are also attributable to false echoes, probably caused by ducting of echoes from nearby trees during stable conditions. As can be seen from Figures 4 and 5 and Appendix B, the impact of these false echoes on the overall data set is small.

Careful inspection of the Benicia sodar records indicates that the relatively frequent occurrence there of ambiguous surface echoes is rarely attributable to false echoes. Rather, it appears to be associated with the special atmospheric conditions there, namely a very strong marine inflow (high winds and turbulence), a strong, low subsidence inversion, and the horizontal inhomogeneity of the local terrain and surface characteristics. (The site is located where the terrain descends into the Carquinez straits; the diurnal flow pattern which advects air past the site can thus be quite complicated and can produce a variety of unusual surface echoes.)

This project produced a data set that can easily be used for boundary layer and pollution studies by a person with no sodar expertise, and the symbol conventions will protect the user from many of the pitfalls that could be caused by siting and equipment problems if a different code were used. Nevertheless, these siting and equipment problems are described here at some length, with the intent of positively influencing future field studies. We believe that site selection and equipment maintenance are of paramount importance in determining the quality of sodar data. Conversely, the quality of the sodar data should be reflected in the digital data set, so that unwarranted inferences are prevented yet the maximum amount of reliable information is preserved.

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Appendix A

LISTINGS OF DIGITAL SODAR DATA WITH SYMBOL CODE

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LISTINGS OF DIGITAL SODAR DATA WITH SYMBOL CODE

This appendix presents hourly digital synopses of atmospheric mixing behavior derived from the sodar facsimile records at the six 1978 network sites. The format and symbols used were chosen to satisfy three objectives:

- Compact storage and display
- Ease of comprehension by a human reader
- Ease of input to and use by a computer model.

Each line of data shown is essentially the same as a corresponding computer card. (Each card includes a month-site indicator, which is omitted from the printed line for clarity). Each line (card) has 25 entries, giving hourly average data centered on each hour from 0000 to 2400 PDT, inclusive. (The use of 25 values per card facilitates conversion to 24 hours of standard-time (PST) data for each date.)

Two lines (cards) of sodar data are printed for each site-day. The first line (card) gives mixing-depth estimates in tens of meters above the sodar. The second line (card) gives a surface-echo type indicator for each hour. Table A-1 summarizes the meaning of the numbers and symbols used.

Several points in Table A-1 require amplification. The first regards the conditions in which the mixing-depth estimate is only an upper bound. The mixing-depth estimate is the height (see discussion below) of the lowest unambiguous layer echo. (A "layer echo" is a sodar echo that tends to be continuous in time and slowly varying in height). Layer echoes mark regions of atmospheric stability. Thus if the layer echo is elevated and there are no other stable layers below it, the base of the layer echo marks the mixing top. However, the sodar record may sometimes show a surface-based echo that is ambiguous (not clearly a

Table A-1

NUMBER AND SYMBOL CODE FOR DIGITAL SODAR DATA

(a) First Line or Card: Mixing Depth

Entry	Meaning	Relationship to Sodar Facsimile Record
$1 \leq n \leq 98$	Mixing depth* (tens of meters above sodar)	Height† of lowest unambiguous layer echo (tens of meters above sodar)
0	If surface echo indicator ≠ X: questionable mixing depth or if surface echo indicator = X: missing data	If surface echo indicator ≠ X: questionable layer height or if surface echo indicator = X: missing data
99	Mixing depth more than 600 m above sodar‡	No echo layer below 990 m above sodar‡

(b) Second Line or Card: Near-Surface Stability Indicator

Entry	Meaning	Relationship to Sodar Facsimile Record
-	Stability	Layer echo at surface
blank	Undefined	No echo at surface
1	Convection	Spike echoes at surface
?	Questionable	Surface echoes are present but cannot be unambiguously classified
X	Missing data	Missing data

*Note: If near-surface stability indicator is ?, "mixing-depth" number is to be interpreted only as an upper bound. The combination of "99" for mixing-depth entry and "?" for surface-echo entry thus should be interpreted as "No mixing-depth measurement."

†If layer is on ground (i.e., surface-echo type indicator = -), "height" is height of layer top; if layer is aloft (i.e., surface echo type indicator = 1, ?, or [blank]), "height" is height of layer bottom.

‡Mixing-depth inference is more conservative than layer-echo indication; comparisons have shown that weak (≤1 degree C) inversions more than 600 m above the sodar are sometimes not detected by the moderately powered sodars used in this study.

spike echo or a layer echo). When such an ambiguous surface echo occurs, the surface-echo type indicator is set equal to "?," and the base height of the lowest unambiguous layer echo is entered as the mixing-depth estimate. In such conditions the ambiguous surface echo may indicate stable air at the surface; if this is so, then the mixing top is below the base of the lowest unambiguous layer echo (which is entered as the mixing-depth estimate). When "?" occurs as the surface-echo type indicator, the associated mixing-depth estimate must therefore be looked upon strictly as an upper bound.

As a practical matter, ambiguous surface echoes occur mainly in the evening, night, and morning, when the lowest unambiguous layer echo height (entered as the mixing-depth estimate) is usually small compared to daytime values. Thus, the practical impact of the mixing-depth number being an upper bound, rather than a best estimate, is often slight (since the upper bound is a small number). Nevertheless, exceptions to this rule do occur, and in such cases the difference between the designators "upper bound" and "best estimate" can be important. This point is pursued in Section VI of the main text.

The second point concerns the choice of layer-echo top or bottom as the best estimate of mixing depth. When the layer echo being described is off the ground (i.e., the surface-echo type indicator is blank, ?, or 1), the base of the layer echo is taken as the mixing depth, because numerous studies have shown that the layer echo base usually coincides with the base of an elevated layer of stable air. On the other hand, when the lowest echo is on the ground (i.e., the surface-echo type indicator is -), the top of the layer echo is taken as the mixing depth. This is because the top of the ground-based layer echo represents either the top of the ground-based inversion or the top of the layer where turbulence has mixed surface-cooled air upward to establish the ground-based inversion. The limit for upward mixing of surface-cooled air should also be the limit for upward mixing of surface-generated pollutants. Hence, this value is entered as the mixing-depth best-estimate on the cards. In addition, comparison studies* have shown that the top of the ground-based acoustic layer echo usually coincides with the ground-based haze top, provided sufficient time has elapsed for the mixing process to establish a well-defined haze top.

We recognize that the strength of upward mixing within a ground-based inversion is much less than the strength of convective mixing. This is the reason for having an indicator of surface-echo type to distinguish between stable layers and convection at the surface. In some modeling applications, the mixing depth is sometimes taken to be zero when a ground-based inversion is present. The user of the present data set has the option of following this practice simply by using an IF statement to set mixing depth equal to zero whenever the surface-echo type indicator is –. If, however, the user chooses to use a nonzero mixing depth and reduced strength of vertical mixing during occurrences of ground-based stable layers, the information required by this procedure is also given in the data set.

The remaining pages of this appendix present the sodar data printouts.

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*For example, Russell et al., 1974: A comparison of atmospheric structure as observed by monostatic acoustic sounder and lidar techniques. J. Geophys. Res., 79, 5555-5566.

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 1, NAPA UTMX=563, UTMY=4236, SODAR HT= 5 M ASL

AUGUST 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	21	20	21	23	20	19	5	4
1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1	1				?	?
2)	4	5	9	3	5	6	4	20	23	24	25	31	28	27	27	24	24	20	22	22	19	8	8	11	6
2)	?	?	?	?	?	?	-	1	1	1	1	1	1	1	1	1	1	1	1	1					?
3)	6	6	7	6	10	3	16	5	13	24	26	31	36	29	20	24	27	22	14	12	10	0	0	0	0
3)	?	?		?		?		?	1	1	1	1	1	1	1	1	1	1	1			?	?	?	?
4)	0	14	6	11	10	24	25	22	20	25	36	40	38	32	22	20	22	19	10	12	16	15	10	17	18
4)	?								1	1	1	1	1	1	1	1	1	1							
5)	18	15	0	10	11	10	8	4	10	14	16	20	18	15	21	18	17	16	14	11	10	15	18	18	20
5)			?			?			1	1	1	1	1	1	1	1	1	1							
6)	20	15	4	7	4	5	5	5	12	16	22	22	20	18	99	18	16	18	20	18	15	18	18	12	14
6)			-						1	1	1	1	1	1	1	1	1	?	?						
7)	14	14	8	6	8	4	6	6	18	21	30	37	40	34	32	32	29	17	14	15	18	11	7	3	12
7)				-				-	1	1	1	1	1	1	1	1	1	1							
8)	12	15	9	4	4	13	7	6	16	21	26	23	22	25	16	17	20	16	23	17	18	20	22	10	14
8)		?		-	-			?	1	1	1	1	1	1	1	1	1	1	1	?					
9)	14	14	10	20	16	5	6	8	16	23	31	29	26	24	18	21	26	20	20	12	12	11	14	0	0
9)						-	-	?	1	1	1	1	1	1	1	1	1	1	1					?	?
10)	0	6	12	11	10	12	14	13	25	24	28	34	40	36	34	23	24	18	18	10	11	13	6	8	7
10)	?	?						1	1	1	1	1	1	1	1	1	1	1	1	1			?		
11)	7	8	4	4	6	8	11	8	7	31	41	42	35	35	17	16	28	36	40	48	9	14	14	17	15
11)		?	-	-					1	1	1	1	1	1	1	1	1	1	1						
12)	15	10	4	0	8	8	14	4	19	46	48	40	99	99	99	99	99	99	34	35	30	19	14	16	8
12)			-	?	?	?		-	1	1	1	1	1	1	1	1	1	1	1	1					
13)	8	4	16	16	4	15	5	5	14	23	30	42	42	99	99	99	99	99	99	99	28	23	24	17	8
13)		-			-		-		1	1	1	1	1	1	1	1	1	1	1						
14)	8	4	6	10	8	6	8	8	6	17	26	31	41	99	99	99	99	99	16	15	16	4	4	5	4
14)		-							1	1	1	1	1	1	1	1	1	1	1			-	-	-	-
15)	4	21	4	8	5	6	5	25	28	22	28	29	29	25	26	24	25	30	18	15	23	9	15	14	10
15)	-		-		-	-			1	1	1	1	1	1	1	1	1	1	1	1					
16)	10	41	45	48	55	53	46	45	30	37	43	49	70	99	99	99	99	36	40	35	48	42	4	4	4
16)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				-	-	-
17)	4	14	6	4	7	7	6	7	6	38	42	37	33	99	99	99	99	99	99	99	4	5	5	6	4
17)	-		-	-					1	1	1	1	1	1	1	1	1	1	1		-	-	-	-	-
18)	4	5	4	4	5	7	7	7	5	26	28	28	35	99	99	99	99	99	99	99	8	3	14	12	9
18)	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1		?	-	1	1	1
19)	9	9	5	5	6	6	7	0	5	9	27	24	99	99	99	99	99	15	16	19	17	16	18	4	3
19)	1	1	?	?	1	1	1	?	1	1	1	1	1	1	1	1	1	1	1	1				-	-
20)	3	4	4	4	3	3	4	5	5	6	21	36	48	37	99	99	99	99	39	19	24	12	18	5	5
20)	-	-	-	-	-	-	-	-		1	1	1	1	1	1	1	1	1	1					-	-
21)	5	17	6	7	4	5	6	8	4	33	47	99	99	99	99	99	99	99	99	99	12	28	15	8	4
21)	-		-	-	-	-	-			1	1	1	1	1	1	1	1	1	1						
22)	4	5	5	4	4	5	4	7	11	21	32	42	99	99	99	99	99	99	99	99	28	4	4	4	7
22)		-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1			-	-	-	
23)	7	11	11	12	5	0	4	5	5	21	99	99	99	99	99	99	99	99	99	99	28	9	10	11	14
23)						?	-	-	-	1	1	1	1	1	1	1	1	1	1						
24)	14	6	14	0	0	4	4	8	7	20	99	99	99	99	99	99	99	99	99	99	99	99	99	4	4
24)				?		-	?		1	1	1	1	1	1	1	1	1	1							
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 2, BENICIA UTMX=575, UTMY=4213, SODAR HT= 49 M ASL

JULY 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
27)	7	5	9	5	8	14	10	8	16	15	34	32	32	32	34	99	34	26	25	25	16	8	8	34	34
27)			-			?	?		1	1	1	1	1	1	1	1	1	1	1	1				?	?
28)	34	14	16	14	15	17	20	24	18	32	33	34	37	30	36	12	16	20	26	21	6	5	8	5	5
28)	?								1	1	1	1	1	1	1	1	1	1	1	1			-		
29)	5	6	15	20	24	28	34	34	35	34	18	15	10	25	18	18	18	21	18	19	15	8	8	5	5
29)									1	1	1	1	1	1	1	1	1	1	1		?	-	-		
30)	5	5	5	5	6	8	15	8	15	18	17	11	10	12	12	9	11	12	18	5	3	3	5	3	10
30)							?		1	1	1	1	1	1	1	1	1	1	?						-
31)	10	8	8	11	12	4	6	5	5	6	9	8	8	8	10	17	20	99	10	10	3	3	3	3	8
31)	-	-	-	-	-	?				1	1	1	1	1	1	1	1	1	1						-
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 2, BENICIA UTMX=575, UTMY=4213, SODAR HT= 49 M ASL

AUGUST 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1)	8	14	6	6	6	5	5	7	7	6	6	6	8	9	14	14	14	7	10	10	5	4	7	6	5
1)	-	-									1	1	1	1	1	1	1	1	?						
2)	5	6	11	14	17	18	18	17	15	12	10	10	10	10	8	0	0	0	0	5	8	4	4	5	13
2)				?	?	?	?	?	1	1	1	1	1	1	?	?	?	?	?	?					
3)	13	10	14	15	16	16	17	18	20	25	20	18	15	16	18	18	17	20	17	0	3	3	9	5	5
3)				?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	?	?	?	?		
4)	5	3	6	8	3	3	6	4	7	9	6	8	9	11	14	23	44	10	4	4	7	3	6	6	8
4)		-	-	-	-	-	?	?	?	?	?	?	1	1	1	1	1	?			-		-	-	-
5)	8	5	3	3	5	8	5	4	11	10	8	8	21	18	8	9	12	99	16	5	4	3	6	3	4
5)	-				-	-		-	-	-	-	-	?	?	1	1	1	1	?				-		
6)	4	9	7	4	6	5	6	3	7	5	5	8	11	9	8	9	19	99	0	5	7	4	6	5	8
6)		-	?		-	-	-		?	?	?	1	1	1	1	1	1	1	?				-		
7)	8	5	5	6	9	7	4	5	7	9	8	8	14	19	20	15	14	0	19	18	3	3	3	7	10
7)										?	?	?	1	1	1	1	1	?							
8)	10	9	7	6	5	6	6	5	5	7	6	9	8	7	13	13	15	16	15	4	3	3	4	6	6
8)										?	?	?	1	1	1	1	?	?	?					-	
9)	5	6	6	6	7	6	5	4	8	8	6	8	9	12	13	22	0	0	5	4	5	3	3	6	4
9)							?	?	1	1	1	1	1	1	1	1	1	1			-			-	
10)	4	4	12	8	10	12	13	10	8	12	15	15	25	33	20	22	24	24	27	8	5	4	4	4	4
10)			?	?	?	?	?			1	1	1	1	1	1	1	1	1	1						
11)	4	4	3	4	6	8	9	9	8	8	8	27	31	26	20	22	26	28	27	25	12	10	8	7	8
11)										1	1	1	1	1	1	1	1	1	1						
12)	8	0	7	8	7	8	10	11	32	40	43	48	50	57	54	67	61	62	99	38	49	39	10	14	8
12)		?	-	-	-	?	-		1	1	1	1	1	1	1	1	1	1	1	1					
13)	8	0	28	21	20	5	4	8	40	37	43	99	99	99	99	99	99	99	99	10	10	15	0	3	4
13)		?							1	1	1	1	1	1	1	1	1	1	1				?	-	?
14)	4	8	3	10	5	7	9	3	7	7	6	10	99	99	99	99	99	99	99	99	99	17	8	4	5
14)	?				?	?	?	?	-	-	?	1	1	1	1	1	1	1	1			?	?	-	-
15)	5	5	7	8	4	5	6	7	9	7	8	9	28	32	23	22	20	17	17	15	8	7	7	17	17
15)	-	-							?	?	1	?	1	1	1	1	1	1	1						
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 3, WALNUT CRK UTMX=584, UTMY=4197, SODAR HT= 30 M ASL

JULY 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
28)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	20	21	15	15	5	10	12	21	20
28)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1	1	1		-	-	-	-
29)	20	9	18	27	31	27	15	7	08	29	32	36	19	18	17	13	14	15	16	15	7	4	4	12	13
29)	-	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	?		-		-	-
30)	13	14	19	17	15	12	11	10	26	25	26	34	33	37	46	55	99	99	99	20	7	7	5	13	12
30)	-	-	?	?	?	?	?	?		1	1	1	1	1	1	1	1	1	?		?	?	?	-	?
31)	12	13	13	15	19	20	18	7	14	16	29	26	26	26	99	99	99	99	99	50	12	28	12	11	10
31)	?	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	?	-	?	-	-	-
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 3, WALNUT CRK UTMX=584, UTMY=4197, SODAR HT= 30 M ASL

AUGUST 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1)	10	8	10	15	15	15	15	21	12	12	16	21	34	14	18	16	24	25	25	19	6	5	27	26	25
1)	-	-	-	-	-	-	-	-	?	?	1	?	1	1	1	1	1	1	?	?	-	-	-	-	-
2)	25	15	13	14	16	10	10	10	10	18	0	0	23	0	22	24	19	19	21	6	5	22	23	13	11
2)	-	-	-	-	-	?	?	?	?	?	X	X	1	X	1	1	1	1	?	-	-	-	-	-	-
3)	11	10	7	6	14	10	10	11	16	22	27	29	33	23	36	42	46	31	16	7	10	6	9	8	0
3)	-	-	-	-	?	?	?	?	?	1	1	1	1	1	1	1	1	1		?	?	?	?	?	?
4)	0	8	8	0	0	0	0	0	20	20	14	17	19	20	99	99	15	17	11	10	8	10	8	10	10
4)	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	1	?	?	?	?	?	?	?	?	?
5)	10	0	0	0	9	11	9	10	0	0	0	20	25	33	99	99	99	99	0	26	26	6	6	0	11
5)	?	?	?	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	?	?	?	?	?	?	?
6)	10	8	10	6	9	5	5	8	6	12	16	23	20	22	27	99	99	23	20	4	20	22	20	16	20
6)	?	?	?	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1		?	?	?	?	?
7)	20	8	11	13	13	12	13	10	7	25	32	40	40	38	99	99	99	99	99	3	3	6	6	6	7
7)	?	-	-	-	-	-	-	-	?	1	1	1	1	1	1	1	?	?	?			-	-		-
8)	7	10	13	0	0	0	0	0	0	19	7	12	16	17	19	24	16	14	14	7	7	7	6	6	6
8)	-	-	-	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?				-	-
9)	6	7	8	10	8	7	9	9	17	32	34	35	42	50	48	20	28	15	8	13	10	11	9	8	9
9)	-	-	-	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	-	?	-	?	-	-	-
10)	9	7	8	6	5	18	14	10	12	11	16	10	12	11	20	26	29	19	11	10	10	7	7	6	5
10)	-	-	-	-	-	-	-	?	?	1	1	?	1	1	1	1	1	1	?	?					
11)	5	11	12	12	13	10	10	8	12	22	17	10	22	26	30	28	32	28	28	16	16	12	10	10	10
11)		?	-	?	?	?	?	?	?	?	?	?	?	1	1	1	1	?	?	?	?	?	?	?	?
12)	10	28	0	10	26	28	19	16	30	46	37	24	54	71	68	80	47	47	36	29	21	32	23	30	23
12)	?	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	?	?	?	?	?	?
13)	23	30	17	24	0	10	18	36	35	45	30	29	99	99	99	99	99	99	99	36	26	6	7	10	13
13)	?	?	?	?	?	-				1	1	1	1	1	1	1	1	?	?	?	?	?	?	?	?
14)	13	12	17	10	9	9	4	4	6	11	17	99	99	0	99	99	99	99	99	99	0	4	4	5	6
14)	?	?	?	-	-	-				1	1	1	1	X	1	1	1	1	1		?				-
15)	6	7	7	7	10	6	3	6	0	27	26	48	99	99	99	99	99	99	99	10	6	15	4	7	12
15)	-					-		-		1	1	1	1	1	1	1	1	1	1						
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 4, LIVERMORE UTMX=616, UTMY=4171, SODAR HT=186 M ASL

JULY 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
31)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	99	99	99	20	22	6	6	7	5	5
31)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1	1	1						-
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 4, LIVERMORE UTMX=616, UTMY=4171, SODAR HT=186 M ASL

AUGUST 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1)	5	4	4	9	4	4	5	4	17	19	23	27	30	34	99	99	99	42	34	30	23	7	7	4	4
1)	-			?	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1						-
2)	4	5	5	5	5	5	5	5	20	22	25	24	28	40	44	99	99	99	26	22	10	7	6	5	4
2)	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1					-
3)	4	5	5	5	5	5	4	4	20	23	27	26	29	32	42	99	99	99	22	24	5	4	6	4	5
3)	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1						
4)	5	5	5	4	5	0	4	4	9	17	19	99	99	99	99	99	99	99	99	15	99	0	16	16	6
4)						?	-	-	1	1	1	1	1	1	1	1	1	1				?	?	?	?
5)	6	6	6	0	14	16	16	16	9	10	17	99	99	99	99	99	99	99	99	99	99	99	11	12	8
5)	?									1	1	1	?	1	?	?	?	?	?						
6)	8	10	13	15	8	0	0	11	10	11	23	99	99	99	99	99	99	99	99	99	25	0	0	0	0
6)								?		1	?	?	1	?	?	?	?	?	?	?		X	X	X	X
7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	99	7	8	5	8	4	4
7)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	?	?					-	-
8)	4	8	7	0	0	0	0	0	0	18	23	26	27	99	99	99	99	99	99	99	20	4	10	6	7
8)	-	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1		?		-		
9)	7	9	10	19	19	10	10	10	10	14	22	26	29	0	0	99	99	99	99	16	8	14	7	7	14
9)		?	?	?	?	?	?	?	?	1	1	1	1	X	X	?	?	?	?			?			
10)	14	14	8	8	13	16	18	22	16	17	19	20	26	99	99	99	99	99	24	10	12	17	18	6	7
10)		?			?	?	?	?	1	1	1	1	1	1	1	1	1	1					?		
11)	7	7	7	8	10	19	7	10	12	18	27	99	99	99	99	99	99	99	99	18	10	6	5	7	6
11)		?	?	?	?	?	?		1	1	1	1	1	1	1	1	1	1	1				?	?	?
12)	20	15	16	15	8	12	12	13	36	44	99	99	99	99	99	99	99	99	99	99	99	60	58	54	50
12)									1	1	1	1	1	1	1	1	1	1	1						
13)	50	18	14	14	6	7	0	20	28	46	50	99	99	99	99	99	99	99	0	15	13	4	7	0	8
13)									1	1	1	1	1	1	1	1	1	1	1						
14)	8	9	10	8	6	5	17	18	10	12	9	99	99	99	99	99	99	99	99	14	0	4	4	4	5
14)										1	1	1	1	1	1	1	1	1							
15)	5	6	6	4	10	9	6	8	6	16	20	24	32	99	99	99	99	99	99	14	5	4	12	4	4
15)										1	1	1	1	1	1	1	1	1	1					-	
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SØDAR DATA (HEIGHTS IN 10'S ØF M ABØVE SØDAR)

SITE 5, SAN JØSE — UTMX=599, UTMY=4132, SØDAR HT= 68 M ASL

JULY 1978

CLØCK HØUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
27)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	28	21	22	20	18	16	13	13
27)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1	1	1				
28)	13	15	9	37	35	34	39	42	46	45	42	39	39	37	33	27	28	24	24	21	18	17	20	12	38
28)						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1
29)	38	44	46	46	47	51	51	53	50	49	43	43	42	42	38	33	33	27	25	20	15	17	15	15	18
29)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
30)	18	36	42	44	47	45	45	45	41	37	39	40	40	36	32	28	33	27	17	13	12	11	14	16	16
30)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
31)	16	15	16	12	11	8	6	18	27	26	27	28	37	34	33	26	20	20	16	8	8	11	9	10	12
31)								1	1	1	1	1	1	1	1	1	1	1	1						
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SØDAR DATA (HEIGHTS IN 10'S ØF M ABØVE SØDAR)

SITE 5, SAN JØSE — UTMX=599, UTMY=4132, SØDAR HT= 68 M ASL

AUGUST 1978

CLØCK HØUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1)	12	11	9	6	5	4	5	6	12	22	27	15	15	16	21	21	20	22	22	22	20	17	16	15	14
1)						?		?	1	1	1	1	1	1	1	1	1	1	1	?					
2)	14	7	8	9	5	6	5	7	12	23	26	28	35	37	35	32	24	23	22	21	21	19	17	16	15
2)								1	1	1	1	1	1	1	1	1	1	1	1	1	?	?	?		
3)	15	15	11	15	7	7	6	14	20	27	37	42	43	37	35	28	27	18	16	15	10	10	14	16	14
3)									1	1	1	1	1	1	1	1	1	1	1	1	1				
4)	14	10	12	10	10	12	20	20	22	23	29	26	35	38	36	16	20	16	15	14	9	7	7	5	6
4)			?				1	1	1	1	1	1	1	1	1	1	1	1	?						
5)	6	7	7	9	6	7	8	12	17	20	21	24	28	28	24	21	15	11	15	7	10	10	13	7	9
5)								1	1	1	1	1	1	1	1	1	1	1	1						
6)	9	5	5	6	3	16	9	14	17	19	22	23	27	29	31	25	19	13	15	10	10	11	12	11	6
6)									1	1	1	1	1	1	1	1	1	1	1					?	?
7)	6	5	6	11	0	13	15	20	22	24	23	28	28	26	25	23	20	16	22	16	8	10	11	13	12
7)	?	-						1	1	1	1	1	1	1	1	1	1	1	?	?	?	?			
8)	12	12	14	17	17	17	17	13	20	23	29	28	25	26	25	24	18	15	13	14	14	14	15	14	15
8)								1	1	1	1	1	1	1	1	1	1	1	?	?	?	?	?	?	
9)	15	14	13	13	13	16	15	8	17	21	25	29	35	32	24	20	18	16	16	17	15	14	16	10	10
9)		?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
10)	10	12	14	14	10	15	17	29	33	34	35	30	29	30	27	23	20	22	21	19	16	16	15	14	11
10)								1	1	1	1	1	1	1	1	1	1	1	1	1					
11)	11	11	9	25	23	16	6	6	8	17	23	28	37	43	26	25	25	23	18	13	10	16	18	16	15
11)				?	?	?		1	1	1	1	1	1	1	1	1	1	1	1	1	?	?	?	?	
12)	16	16	19	21	25	31	5	6	24	39	48	57	99	99	99	99	99	99	99	99	99	47	38	24	16
12)		1	1						1	1	1	1	1	1	1	1	1	1	1	1					
13)	16	0	6	18	13	28	30	8	29	27	99	99	99	99	99	99	99	99	36	34	26	18	14	17	5
13)								?	1	1	1	1	1	1	1	1	1	1	1	1	1				
14)	5	11	12	0	6	7	5	10	16	24	28	36	37	99	99	99	99	99	99	15	13	11	16	12	5
14)				?					1	1	1	1	1	1	1	1	1	1	1						
15)	5	4	6	4	5	7	5	5	14	26	29	38	28	30	32	28	24	30	30	13	10	16	15	8	10
15)									1	1	1	1	1	1	1	1	1	1							
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 6, MENLO PARK UTMX=573, UTMY=4145, SODAR HT= 18 M ASL

JULY 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
28)	6	6	6	6	6	6	6	6	7	50	52	54	39	32	30	23	18	16	16	20	18	17	15	12	31
28)	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1		?	?	?	?
29)	31	43	47	52	53	12	11	8	8	56	50	48	48	44	33	31	25	18	20	20	18	14	7	14	7
29)	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1			?	?	?
30)	7	32	47	50	50	51	52	49	49	45	44	41	38	30	22	20	20	14	15	15	13	14	15	14	15
30)	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	1	1		?	?	?
31)	15	11	6	6	6	6	6	6	16	30	30	30	23	19	21	21	16	15	12	11	10	10	11	11	5
31)	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	1				-
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

SODAR DATA (HEIGHTS IN 10'S OF M ABOVE SODAR)

SITE 6, MENLO PARK UTMX=573, UTMY=4145, SODAR HT= 18 M ASL

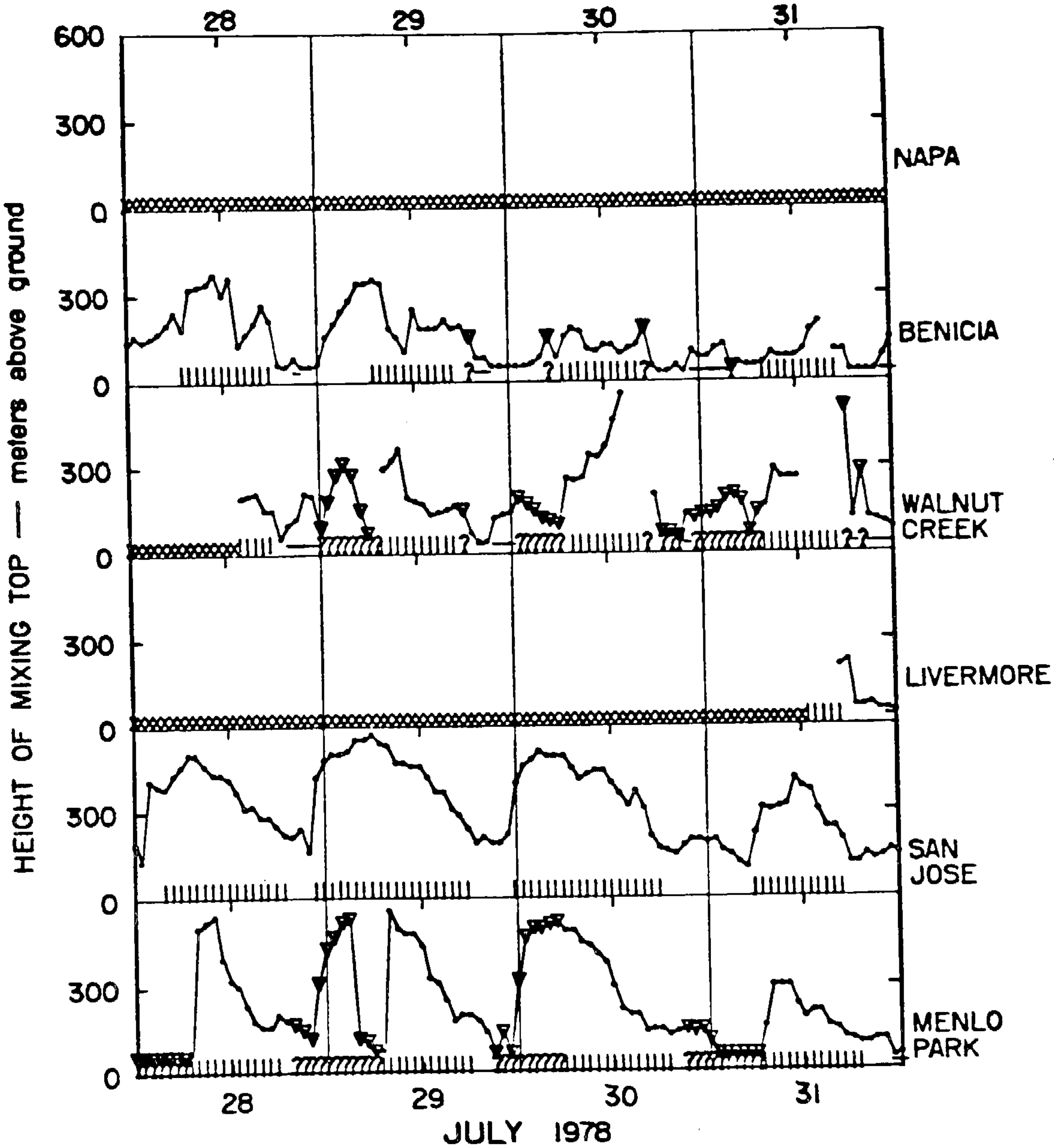
AUGUST 1978

CLOCK HOUR (PACIFIC DAYLIGHT TIME)

DAY /	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1)	5	6	6	6	6	7	7	6	21	31	32	35	33	30	27	18	20	22	22	23	21	21	6	6	6
1)	-	-	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	1		?	?	?
2)	6	14	8	7	35	37	39	41	40	40	34	32	27	28	27	25	23	22	24	24	26	23	23	26	32
2)	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
3)	32	37	38	38	42	42	42	42	43	42	37	35	32	28	26	26	25	18	19	18	19	14	12	17	20
3)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	?	?	?	?
4)	20	21	26	25	18	20	22	16	30	34	31	28	24	23	21	14	13	12	13	13	15	12	10	6	6
4)	?	?							1	1	1	1	1	1	1	1	?	?	?	?	?	?			
5)	6	5	7	7	7	7	7	7	11	22	24	20	15	15	16	16	13	12	12	12	11	13	5	5	5
5)		?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	?			?	-	-
6)	5	5	5	5	4	4	7	13	14	24	27	24	19	18	20	17	14	26	16	16	17	5	7	7	6
6)	-	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	?	?	?	?	?
7)	6	6	5	5	5	5	5	5	12	28	34	28	20	22	0	0	0	0	0	0	0	0	0	0	0
7)	?	-				?			?	1	1	1	1	1	X	X	X	X	X	X	X	X	X	X	X
8)	0	0	0	0	0	0	0	0	0	0	0	0	20	18	18	19	21	12	12	13	7	5	5	5	5
8)	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1	1	1	1	1	?	?	?	?	?	?
9)	5	5	5	6	7	7	7	7	0	0	0	0	0	0	0	0	0	0	0	15	15	12	9	10	13
9)	?	?	?	?	?	?	?	?	X	X	X	X	X	X	X	X	X	X	X	1	1				
10)	13	14	16	14	5	6	18	39	43	40	39	35	32	26	25	24	24	20	20	14	16	15	14	21	21
10)			?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		?	?
11)	21	6	6	5	5	5	6	5	20	28	31	33	22	22	20	12	22	24	13	12	13	6	3	5	21
11)	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	1					
12)	22	10	6	0	4	6	5	6	16	43	0	60	56	99	99	99	99	99	99	99	49	10	12	8	0
12)				?	?	-	-		1	1	1	1	1	1	1	1	1	1	1	1					
13)	0	7	4	0	4	4	4	4	5	50	63	60	45	0	99	99	99	99	19	18	7	6	12	17	16
13)					-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1			?	?	?
14)	16	12	8	6	8	0	0	0	0	0	0	0	0	0	0	0	0	99	38	28	6	4	12	2	10
14)	?	?	?	?	?	X	X	X	X	X	X	X	X	X	X	X	X	1	1			?		?	?
15)	10	8	12	3	7	7	6	6	6	31	32	30	23	27	21	19	17	14	19	15	14	6	3	4	6
15)	?	?	?	?	?	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1			?	?	-
/	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Appendix B

COMPUTER PLOTS OF DIGITAL SODAR DATA



LEGEND;

—•— MIXING-DEPTH BEST ESTIMATE

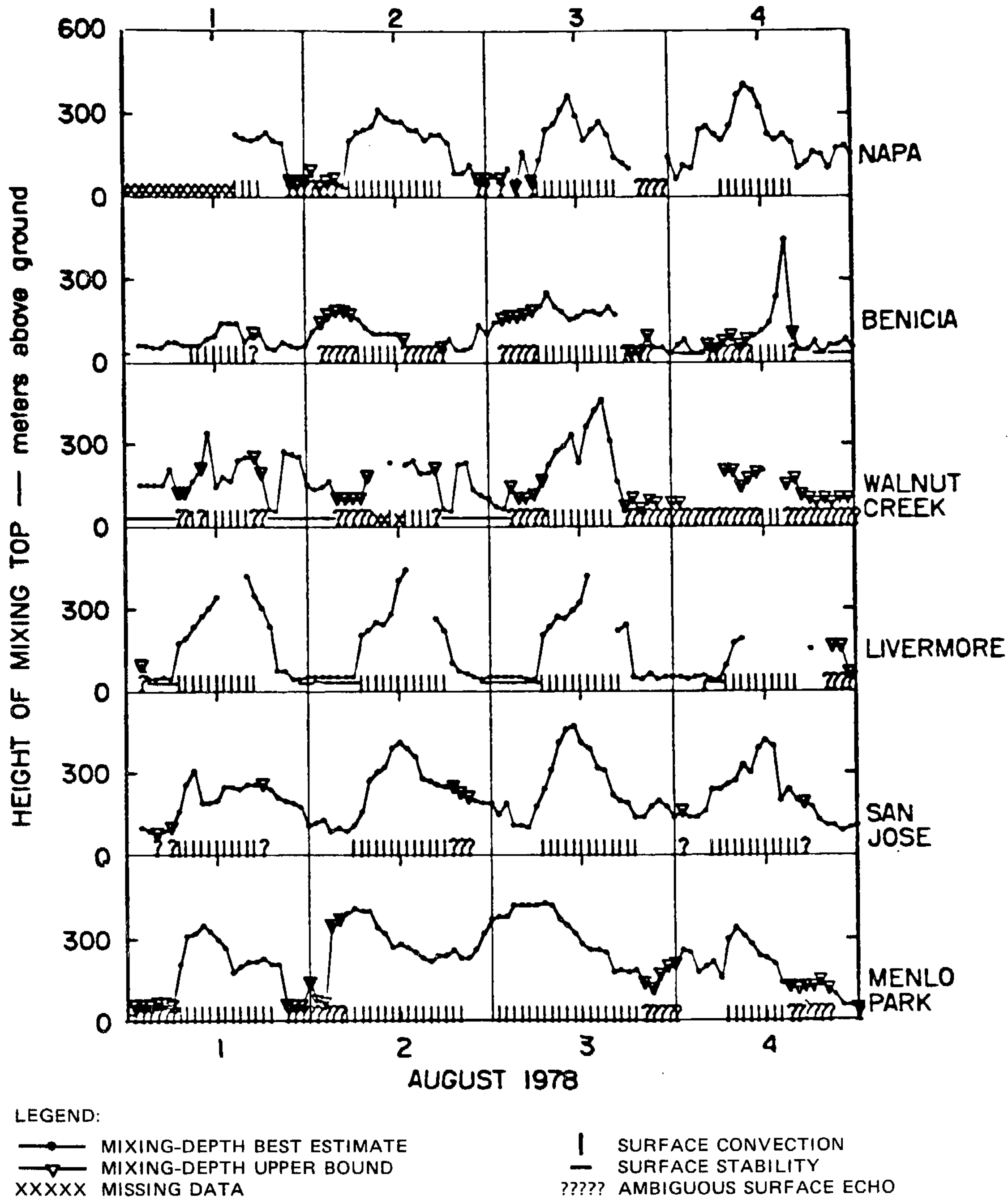
—▽— MIXING-DEPTH UPPER BOUND

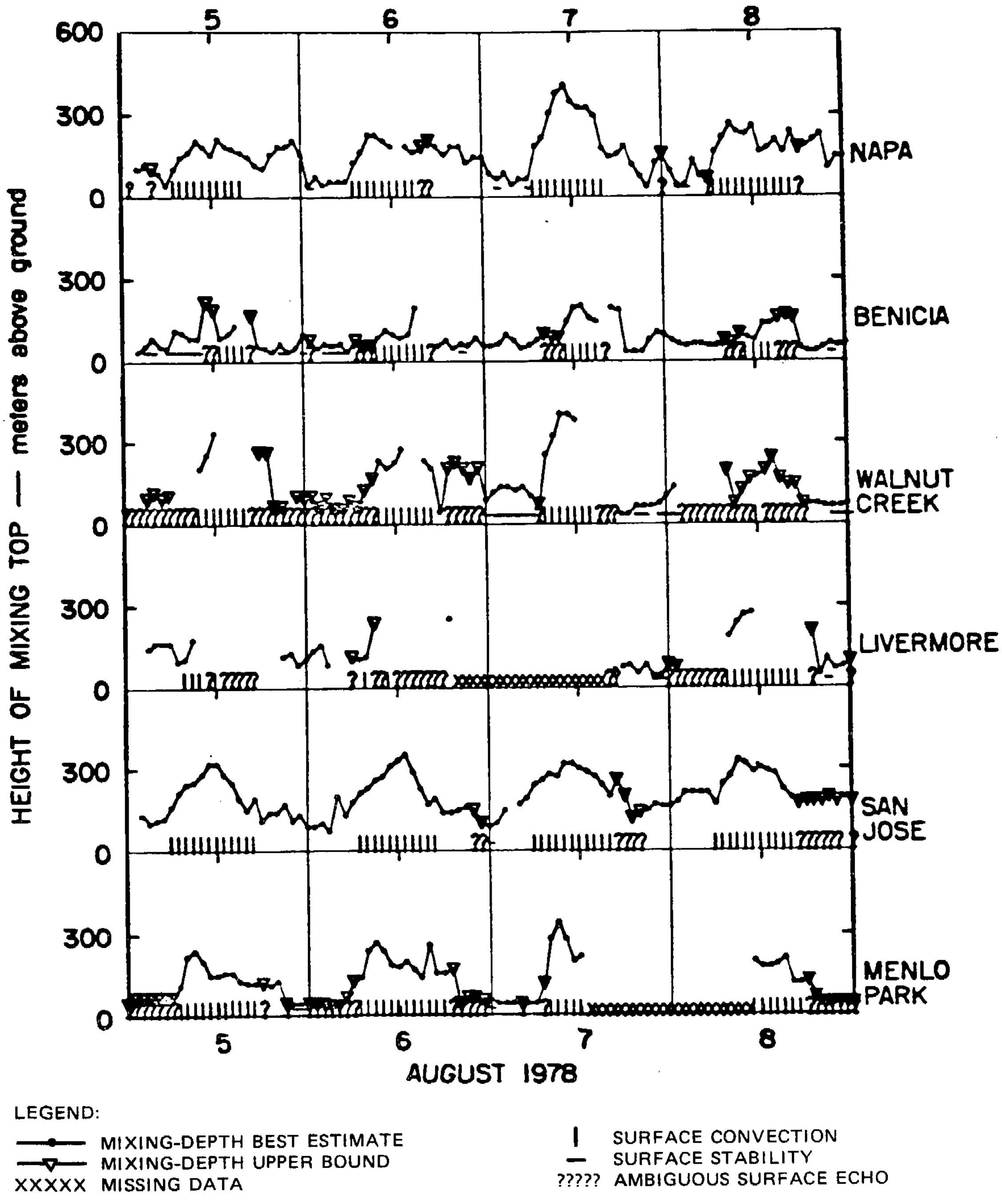
XXXXX MISSING DATA

I SURFACE CONVECTION

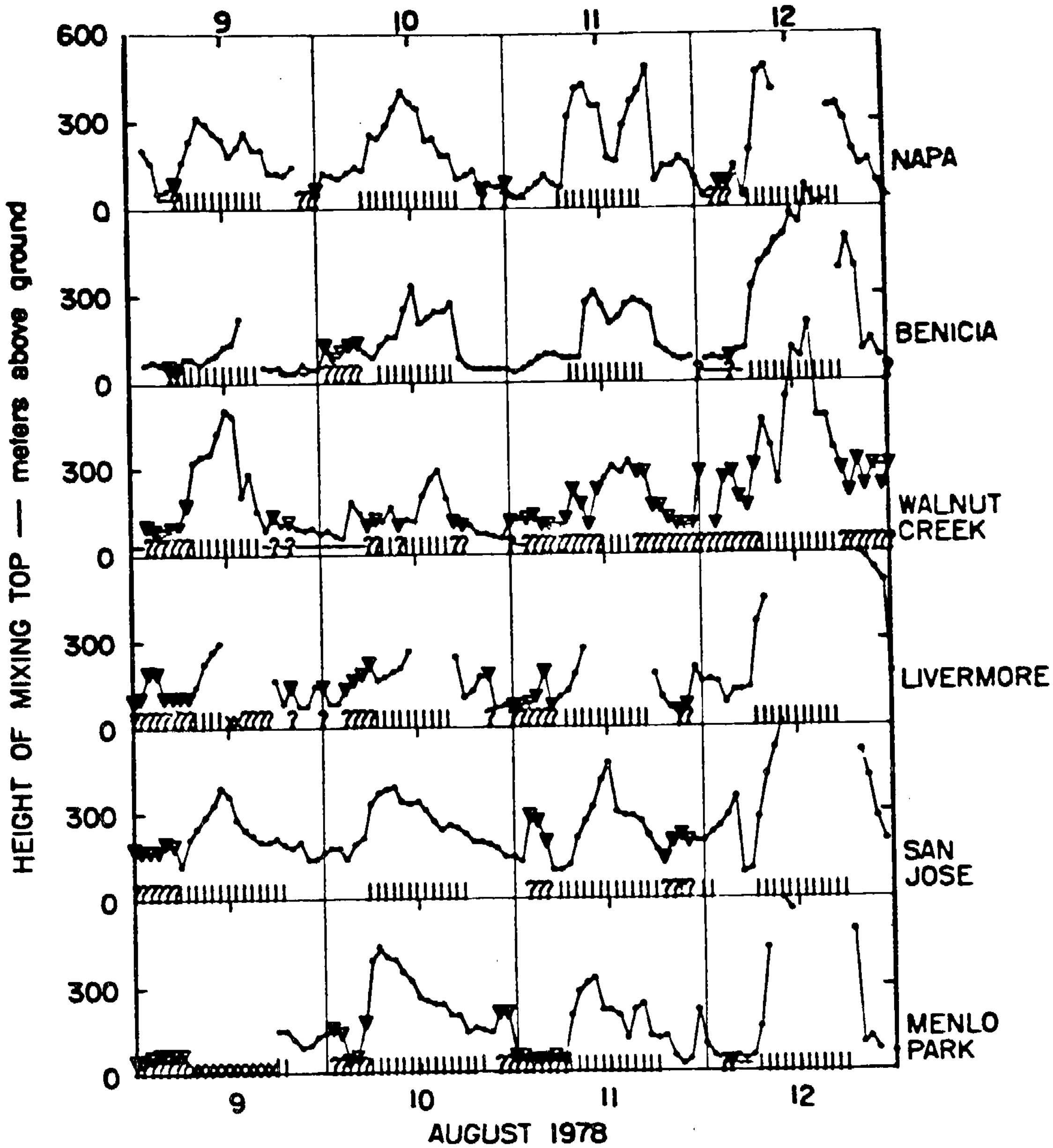
— SURFACE STABILITY

????? AMBIGUOUS SURFACE ECHO


600
300
0
NAPA
BENICIA
WALNUT CREEK
LIVERMORE
SAN JOSE
MENLO PARK
HEIGHT OF MIXING TOP — meters above ground
1
2
3
4
AUGUST 1978
LEGEND:
MIXING-DEPTH BEST ESTIMATE
MIXING-DEPTH UPPER BOUND
XXXXX MISSING DATA
SURFACE CONVECTION
SURFACE STABILITY
????? AMBIGUOUS SURFACE ECHO



600
300
0
5
6
7
8
NAPA
BENICIA
WALNUT CREEK
LIVERMORE
SAN JOSE
MENLO PARK
HEIGHT OF MIXING TOP — meters above ground
AUGUST 1978
LEGEND:
MIXING-DEPTH BEST ESTIMATE
MIXING-DEPTH UPPER BOUND
XXXXX MISSING DATA
SURFACE CONVECTION
SURFACE STABILITY
????? AMBIGUOUS SURFACE ECHO



LEGEND:

MIXING-DEPTH BEST ESTIMATE

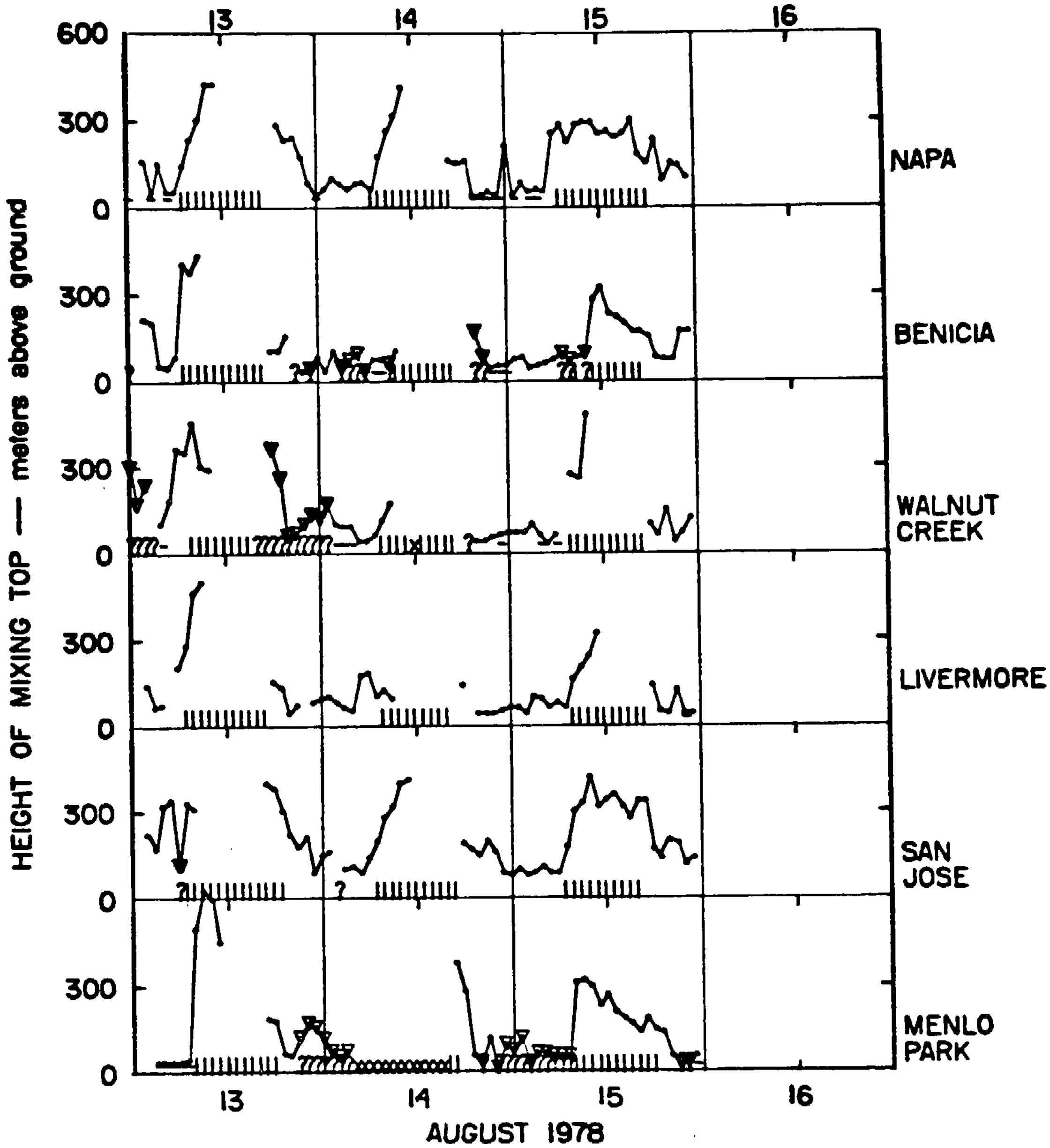
MIXING-DEPTH UPPER BOUND

XXXXX MISSING DATA

I SURFACE CONVECTION

— SURFACE STABILITY

????? AMBIGUOUS SURFACE ECHO



LEGEND:

—•— MIXING-DEPTH BEST ESTIMATE

—▽— MIXING-DEPTH UPPER BOUND

XXXXX MISSING DATA

| SURFACE CONVECTION

— SURFACE STABILITY

????? AMBIGUOUS SURFACE ECHO

50272-101

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

A network of six sodars (acoustic radars) was operated in the San Francisco Bay area from late July to early September 1978. The purpose of the network was to acquire inland mixing-depth data for use by the Bay Area Air Quality Management District in their studies of summer oxidant episodes in conjunction with data from Project MABLE. The sodar data from 28 July through 15 August were reduced to a digital form giving hourly mixing-depth estimates and surface-stability indicators. A computer code was developed to plot these data, thus giving an overview and facilitating comparisons among different sites, days, and times of day.

Listings and plots of the digital data are shown and discussed. The importance of site selection and equipment maintenance to resulting sodar data quality is emphasized through examples.

17. Document Analysis a. Descriptors

Sodar; Acoustic Radar;
Air Quality Modeling;
Mixing Depth; Stability

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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